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Geographically Isolated Wetlands and Intermittent/ Ephemeral Streams in Montana: Extent, Distribution, and Function

Prepared for:

Montana Department of Environmental Quality and
U. S. Environmental Protection Agency

By:

Linda K. Vance

Montana Natural Heritage Program
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Executive Summary

Recent rulings of the U.S. Supreme Court have limited Clean Water Act jurisdiction over actions affecting isolated wetlands and intermittent or ephemeral streams. In a semi-arid environment like Montana, isolated wetlands and impermanent streams are often critical refugia, breeding areas, or food sources for wildlife, and harbor many plant species that could not survive in the surrounding uplands. The purpose of this project was to conduct GIS-based analysis to assist the Montana Department of Environmental Quality in assessing the distribution and extent of the resources affected, including the ecological functions and values they represent.

We used a series of data processing routines and subroutines to identify geographically isolated wetlands. For the purpose of the analysis, we defined geographically isolated wetlands as those palustrine wetlands that met all the following tests: 1) not on a large river floodplain, defined as a 300 meter buffer on either side of the river; 2) more than 40 meters from any perennial or intermittent stream or river, whether or not that stream or river was a tributary of a navigable river; 3) not connected to a wetland that was itself on a large river floodplain or within 40 meters of a perennial stream or river; 4) not within 40 meters of a large (>20 acre) lake or wetland with a perennial stream inflow or outflow; and 5) more than 20 meters from any ephemeral channel. We also used a similar approach to identify wetlands that were likely to fall within Clean Water Act jurisdiction, wetlands that might meet a "significant nexus" test to establish jurisdiction, and wetlands whose classification could not be determined from a GIS. To identify impermanent streams, we used both medium-resolution and high-resolution hydrography data to categorize all streams represented on 1:24,000 topographical maps into perennial, intermittent and ephemeral categories. Finally, we assigned landscape position, landform, water regime and water path attributes to the isolated wetlands we identified, and used these as the basis for rating each isolated wetland type's average performance expectation on each of ten wetland functions.

The analysis showed that of 252,186 natural wetlands currently mapped in Montana, 152,726 -- 61% of all mapped wetlands -- have no visible surface water connection to any other water body. When only palustrine wetlands are considered, 65% of wetlands across the statewide mapped areas are isolated. Palustrine emergent wetlands account for 91% of isolated wetlands. These wetlands characteristically have a short inundation period; 93% have either a seasonally flooded or a temporarily flooded water regime. In terms of wetland acreage, the percentages are lower, simply because geographically isolated wetlands are typically small (less than half the average size of palustrine wetlands). Mapped wetlands in Montana cover some 735,338 acres; of this total, 176,224 acres are geographically isolated. Even in the Northwestern Glaciated Plains, where 50% of palustrine wetlands are geographically isolated, only 30% of the total palustrine acreage is isolated.

By contrast, only 19,314 mapped wetlands in Montana -- less than 8% of the total -- are associated with navigable rivers or large lakes or have a continuous surface water connection to other large rivers. These wetlands are likely to meet the threshold required for an assertion of jurisdiction by the Army Corps of Engineers or the EPA. We identified an additional 31,196 wetlands – almost 13% of all mapped natural wetlands -- that were most likely to have a "significant nexus" to a navigable river or its tributaries, and an additional 327 wetlands that were near large wetlands connected to perennial rivers. The remaining 20% could not be classified using GIS alone.

Our analysis of streams revealed that on a statewide basis, ephemeral and intermittent streams far outnumber perennial ones. In some ecological subsections within the Northwestern Glaciated Plains and Northwestern Great Plains, there were no perennial streams at all. Only in the Canadian Rockies did we find that there were more kilometers of perennial stream than intermittent and ephemeral.

Our examination of wetland function showed that isolated wetlands generally perform the same wetland functions as wetlands connected to navigable rivers, although they sometimes performed at a higher level or lower level. Overall, isolated wetlands rank high on habitat functions and for their contribution to wetland biodiversity. Although we did not conduct the same level of analysis on intermittent and ephemeral streams, we noted that these features typically perform the same functions as isolated wetlands.

This analysis indicates that many of Montana's wetlands and streams will not meet the thresholds for Clean Water Act jurisdiction or will require a site-specific investigation of "significant nexus" to establish jurisdiction, which may create an unrealistic workload for agency personnel charged with making jurisdictional determinations. At the same time, it leaves landowners and resource managers in a state of uncertainty, not knowing what actions will require permits and not being able to predict how much time it will take to process a request.

Acknowledgements

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Several people assisted with the GIS work, wetland mapping, and analysis. Jane Horton, now of Montana Fish, Wildlife and Parks, built the original analytic template. Joey Diehl of the MTNHP Spatial Analysis Lab created several datasets. Meghan Burns, Sloane Gray, Cat McIntyre and Karen Newlon of MTNHP all worked on mapping and quality control. Erika Colaiacomo of MTNHP helped with data analysis. David Stagliano provided input on stream and river classifications. All photos were taken by MTNHP staff unless otherwise noted.

Portions of this project were presented to the Montana Wetland Council and at the Western Wetland Monitoring and Assessment Workgroup conference. Thanks to the many Council and Workgroup members who asked helpful questions and offered suggestions.

Finally, thanks are due to Sue Crispin, MTNHP director, for her editorial review , and to Coburn Currier of MTNHP for his work formatting and editing the final version. Any errors that remain are mine alone.

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Introduction

The Goal of this Study

Over the past few years, the federal courts have issued a number of rulings in cases challenging the authority of the Army Corps of Engineers and the Environmental Protection Agency to regulate wetlands under the Clean Water Act. In 2006, the U.S. Supreme Court issued several opinions in the consolidated cases *Rapanos* v. *United States*, and *Carabell* v. *United States*, 126 S.Ct. 2208 (2006) (hereafter referred to as *Rapanos*), articulating new -- and sometimes contradictory -- legal standards for applying the Clean Water Act to actions affecting wetlands. In their ruling, the plurality also articulated a restricted scope of protection for intermittent and ephemeral streams, especially those at a distance from traditionally navigable waters.

The State of Montana does not have a regulatory program for wetlands. In the absence of Clean Water Act protection, there are few legal constraints on actions that impair wetland health or compromise wetland function. To assist the Department of Environmental Quality and US-EPA in assessing the implications of this change, we undertook a GIS-based analysis to determine the nature and extent of wetlands and intermittent/ephemeral streams that may lie outside Clean Water Act jurisdiction. We emphasize the word "may": this is a GIS analysis, based on maps that themselves do not determine jurisdictional status, and it should in no way enter into any findings of fact or law by any decision-making authority. Instead, our purpose was to provide resource managers, lawmakers, landowners and the public with additional information on the extent and significance of the wetlands in question. In a semi-arid environment like Montana, wetlands and ephemeral streams are often critical refugia, breeding areas, or food sources for wildlife, and harbor many plant species that could not survive in the surrounding uplands. We wanted to identify the size of the resource that may be unprotected, and to highlight the functions and values that could be lost if these wetlands and streams were to disappear or lose their ecological integrity.

In the following pages, we give a brief overview of the legal background, and describe the kinds of wetland and stream resources found in Montana. This is followed by a description of the methods we employed in our analysis, and the results we found. In the final section of the report, we discuss the implications for wetlands and ephemeral streams in particular, and for Montana's ecological systems as a whole.

Legal Background

The federal Clean Water Act was enacted "to restore and maintain the chemical, physical and biological integrity of the Nation's waters."[1] To this end, the Act prohibits the discharge of any pollutant, including dredged or fill materials, into "navigable waters"[2] -- defined as "waters of the United States"[3] -- unless specific requirements of the Act have been complied with. In the case of wetlands, this typically means obtaining a "dredge and fill" permit (better known as a "Section 404 permit") from the Army Corps of Engineers.[4]

The terms "navigable waters" and "waters of the United States" are not defined in the Clean Water Act itself, but rather in regulations issued by the Army Corps of Engineers (ACOE) and the Environmental Protection Agency (EPA). Specifically, the regulations provide that:

a. The term "**waters of the United States**" means
    1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
    2. All interstate waters including interstate wetlands;

[1] 33 U.S.C. § 1251(a)
[2] 33 U.S.C. § 1344(a)
[3] Navigable waters, according the Act, are "the waters of the United States, including the territorial seas." 33 U.S.C. § 1362(7)
[4] 33 U.S.C. § 1344(a) and (d)

3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
   i. Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
   ii. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
   iii. Which are used or could be used for industrial purpose by industries in interstate commerce;
4. All impoundments of waters otherwise defined as waters of the United States under the definition;
5. Tributaries of waters identified in paragraphs (a)(1)-(4) of this section;
6. The territorial seas;
7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a)(1)-(6) of this section;
8. Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with the EPA.[5]

Because the permitting process can be both lengthy and expensive, and because an unpermitted discharge of dredged material or fill can trigger criminal liability, these regulations have been challenged repeatedly in the federal courts. For example, in *United States* v. *Riverside Bayview Homes, Inc.*, 474 U.S. 121 (1985), petitioners challenged the ACOE's determination that wetlands adjacent to larger bodies of water fell under the Clean Water Act. The U.S. Supreme Court upheld the determination in that case, ruling that the wetlands' hydrological connection to waters of the United States was enough to establish jurisdiction. However, in *Solid Waste Agency of Northern Cook County* v. *U.S. Army Corps of Engineers (SWANCC)*, 531 U.S. 159 (2001), a split court (5-4) ruled that isolated wetlands did not fall within the scope of the Clean Water Act merely because they were used by migratory birds; Clean Water Act jurisdiction depended on a "significant nexus" being shown between the wetland and waters of the United States.

The recent Supreme Court case referred to as *Rapanos* dealt with the meaning of "navigable waters" in the context of wetlands adjacent to tributaries of those waters. Five of the justices concurred in the result, which was to remand the cases to the Sixth Circuit Court of Appeals for reconsideration, but the underlying reasoning for that result was only supported by four justices. This is referred to as a "plurality opinion," which lacks authority as a precedent. Instead, lower courts can either follow the plurality opinion, or consider the opinion of the fifth justice to be controlling. In *Rapanos*, the plurality opinion concluded that the Clean Water Act's provisions applied only to "relatively permanent, standing or continuously flowing bodies of water" connected to traditional navigable waters, and that only wetlands "with a continuous surface water connection" to those relatively permanent waters could be considered to be adjacent wetlands for the purposes of jurisdiction.[6] The plurality therefore remanded the case to the lower court to decide if the waters in question fit this standard and if the wetlands in the case were indeed adjacent. Justice Kennedy agreed that the case should be remanded, but ruled that the appropriate test for the lower courts to apply was the "significant nexus" test. Wetlands would be "waters of the United States," he concluded, "if the wetlands, either alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical and biological integrity of other covered waters more readily understood as navigable."[7]

[5] 33 C.F.R. § 328.3(a). (emphasis added). The EPA's identical definitions are found at 40 C.F.R. § 230.3(s)
[6] 126 S.Ct. 2208 (2006), at 2225-2227
[7] Id. At 2248

In the months immediately following the *Rapanos* decision, it was not clear which test or tests would apply. However, several lower courts held that the relevant test should be the "significant nexus" test.[8] In 2007, the Court of Appeals for the Eleventh Circuit ruled that Justice Kennedy's standard should be the sole method of determining jurisdiction.[9] The government sought to appeal that ruling to the U.S. Supreme Court via a writ of certiorari, which was denied on December 1, 2008. The denial of certiorari effectively endorses the Eleventh Circuit's ruling.

On June 5, 2007, the ACOE and EPA headquarters (with input from the Department of Justice and other federal agencies) issued joint guidance to EPA regions and ACOE districts on the interpretation and application of *Rapanos*.[10] Following public comment and the denial of certiorari by the Supreme Court, the agencies revised their guidance on December 2, 2008, clarifying several key points.[11] The original and revised guidance documents articulate the agencies' position that they will assert jurisdiction over :

- Traditional navigable waters
- Wetlands adjacent to traditional navigable waters
- Non-navigable tributaries of traditional navigable waters that are relatively permanent
- Wetlands that directly abut such tributaries

Following a fact-based analysis to determine if there is a "significant nexus" with navigable waters, jurisdiction will be decided on a case-by-case basis for:

- Non-navigable tributaries that do not typically flow year-round or do not have continuous flow at least seasonally
- Wetlands adjacent to such tributaries
- Wetlands adjacent to but that do not directly abut a relatively permanent non-navigable tributary

"**Traditional navigable waters,**" as defined in the revised guidance, are 1) waters defined as navigable under section 9 or 10 of the Rivers and Harbors Act, or 2) waters determined by a federal court to be navigable-in-fact, or 3) waters currently being used, historically having been used, or susceptible to being used for commercial navigation, including commercial water recreation (e .g . boat rentals, guided fishing trips, water ski tournaments, etc.).

"**Adjacent wetlands**" are wetlands satisfying one of three tests: 1) an unbroken surface or shallow subsurface connection, which may be intermittent, to a jurisdictional water; or 2) a physical separation from jurisdictional water consisting only of man-made dikes or barriers, natural river berms, beach dunes, etc. or 3) reasonable proximity supporting a science-based inference of ecological interconnection. The guidance clarifies that this inference will not be made on a case-by-case basis, but rather rests on scientific knowledge, such as knowledge that fish typically move into such wetlands to spawn.

A "**non-navigable tributary**" that is "relatively permanent" is one that flows into a traditional navigable water, whether directly or through other tributaries, and typically flows year round, except in drought years, or flows continuously during a three-month season. The agencies will assert jurisdiction over these tributaries without a "significant nexus" finding. The guidance specifically excludes "ephemeral tributaries which flow only in response to precipitation, and intermittent streams which do not typically flow year-round or have continuous flow at least seasonally" but notes that jurisdiction over those non-permanent streams will be evaluated on a case-by-case basis under the "significant nexus" test.

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[8] See e.g. *San Francisco Baykeeper* v. *Cargill Salt Division* 481 F.3d 700 (9th Cir. Mar. 8, 2007); *United States* v. *Gerke Excavating, Inc.* 464 F.3d 723 (7th Cir. Sept. 22, 2006; *Northern California River Watch* v.*City of Healdsburg*, 457 F.3d 1023 (9th Cir. Aug. 10, 2006); *Environmental Protection Information Center* v. *Pacific Lumber Cp.* 469 F. Supp. 2d 803 (N.D. Cal, Jan 8, 2007).

[9] *United States* v. *McWane, Inc, et al.* 505 F.3rd 1208 (11th Cir. 2007)

[10] The guidance is available at http://www.epa.gov/owow/wetlands/pdf/RapanosGuidance6507.pdf

[11] The revised guidance can be found at http://www.epa.gov/wetlands/guidance/CWAwaters.html

A "**significant nexus**" finding is based on a number of hydrologic factors, including but not limited to flow factors (volume, duration and frequency); proximity to traditional navigable waters; size of the watershed, the annual rainfall, and the annual snow pack, AND on ecological factors such as the tributary's potential to carry pollutants and flood waters, the extent to which it provides aquatic habitat to support the traditional navigable water (e.g. headwater spawning areas), and the potential of adjacent wetlands to trap pollutants, store floodwaters, or otherwise maintain water quality in traditional navigable waters.

Although the guidance explicitly states that swales, gullies and ditches are generally not waters of the United States, they may still serve as a surface connection between an adjacent wetland and a traditional navigable water, and may still fall under other provisions of the Clean Water Act if they function as point sources of pollution. The guidance also notes that these features must be distinguished from ephemeral streams, pointing out ephemeral tributaries may collect and transport water and sediment from uplands to jurisdictional waters, and in general may support functions that affect the "chemical, physical and biological integrity" of traditional navigable waters. Therefore, it may be inferred from the guidance that a "significant nexus" may also exist between navigable waters and ephemeral streams, but that this will have to be determined on a case-by-case basis.

Despite the guidance interpreting the *Rapanos* decision in a manner that allows for broad application of the Clean Water Act if a "significant nexus" can be established, neither the guidance nor recent court decisions have retreated from the position taken in *SWANCC*, so that most geographically isolated wetlands are still outside Clean Water Act jurisdiction. The guidance specifically disclaims any applicability to the *SWANCC* decision and provides that earlier guidance on that decision is still in effect. Further, the recent 9th Circuit ruling in *San Francisco Baykeeper* v. *Cargill Salt Division*, 481 F.3d 700 (9th Cir. March 8, 2007) also reaffirmed the continuing applicability of the *SWANCC* decision.

In short, then, wetlands fall into one of three categories relative to the Clean Water Act: 1) wetlands that are jurisdictional because they are adjacent to navigable waters or abut relatively permanent tributaries of those waters; 2) wetlands that may be jurisdictional, providing that there is a finding of "significant nexus" between that wetland and a traditional navigable water; and 3) wetlands that are not jurisdictional because a "significant nexus" cannot be established.

Wetlands and Ephemeral Streams in Montana

We do not know the precise extent of wetlands or ephemeral streams in Montana. Although the National Wetlands Inventory (NWI) mapped wetlands in the state during the 1980s and early 1990s, the majority of the maps were never digitized.[12] The United States Geological Survey has produced a digital National Hydrography Dataset (NHD) from topographical maps, but ephemeral streams are lumped together with intermittent streams,[13] and cannot be easily quantified.

Mapped wetlands are classified using the Cowardin scheme (Cowardin et al. 1979), a hierarchical approach that classifies wetlands into systems, subsystems and classes. Three broad systems are found in Montana: **Palustrine** wetlands (such as marshes, fens, bogs, beaver ponds, potholes, wet meadows, willow sloughs and forested swamps); **Lacustrine** wetlands (usually associated with sizable playas, extensive marshes, and/or the margins of large or deep lakes); and **Riverine**

[12] The Montana Natural Heritage Program is currently mapping wetlands and riparian areas from 2005 aerial imagery, but only a small portion of the state has been completed. In the past year, the Montana offices of the U.S. Fish and Wildlife Service have arranged to have many of the 1980s-era maps digitized, and these maps are now publicly available. The most extensively mapped portion of the state is the Prairie Pothole Region lying north of the Missouri River.

[13] Intermittent streams typically have both a surface water and a ground water source, even though they do not flow year round. Ephemeral streams have no groundwater source, and flow only during snowmelt or in response to precipitation events.

wetlands (defined as occurring within the active channel of a stream or river). Lacustrine and Riverine systems are further classified into subsystems. Riverine systems, for example, may be Upper Perennial, Lower Perennial, or Intermittent. Classes describe the substrate, or, in the case of Palustrine wetlands, the vegetation life form (e.g. emergent, scrub-shrub, forested, etc). Finally, hydrologic modifiers describe the water regime; permanently flooded, semipermanently flooded, seasonally flooded, and so on.

In the present study, which depends on digital wetland maps analyzed with GIS software and routines, we use the Cowardin classes to summarize our results. One of the shortcomings of the Cowardin system, however, is that the broad systems and subsystems encompass such diverse wetland types it is difficult to make generalizations. For example, a Palustrine emergent wetland can be a prairie pothole, a floodplain oxbow, or a cattail marsh. Potholes, however, are characteristically isolated wetlands, while floodplain oxbows are typically associated with large rivers and streams. Consequently, when we say a certain number of Palustrine emergent wetlands within Montana are geographically isolated, a GIS analysis alone cannot tell us what kinds of wetlands those are. Ephemeral streams are equally difficult to characterize with a GIS. During fieldwork for this and other studies, we have encountered ephemeral streams flowing through sandy canyon bottoms and grassy swales in eastern Montana, draining alluvial deposits in the Prairie Pothole region, and coursing out from under snowfields in the Rockies.

To assign specific ecological characteristics to every isolated wetland and ephemeral stream we identified would be impossible, but we did not want to ignore the differences altogether. One solution, which we have employed here, is to divide the state into EPA Level III ecoregions (Omernik 1987). The ecoregion concept is premised on the idea that distinct ecological regions can be identified by analyzing the patterns and composition of vegetation, climate, soils, land use, hydrology and geology that produce differences in overall ecosystem quality. In Montana, seven distinct ecoregions (see Figure 1) have been described (Woods et al. 2002). These are:

The Canadian Rockies. The Canadian Rockies, as the name implies, are mostly in Alberta and British Columbia but extend south into Northern Montana. In general, this area has the highest elevations and receives the most snow and ice, being influenced by marine air masses from the Pacific. Melting snow and summer rains contribute to a high percentage of perennial streams, and numerous natural lakes. In some areas, crystalline rocks with little storage capacity underlie the surface, and overland runoff is high, with little groundwater storage. In these areas, streams are intermittent or ephemeral, and lack year round flow. In the region as a whole, typical wetland types include wet meadows, fringe wetlands around lakes, beaver ponds, fens, riparian woodlands and shrublands, conifer swamps, avalanche chute shrublands (Figure 2), and wooded vernal pools. Of these, fens, vernal pools, and avalanche chute shrublands -- all Palustrine -- are the most likely to be geographically isolated from permanent surface water. Ephemeral streams typically originate in snowfields and join first- or second-order intermittent streams (Figure 3).

Figure 2. Avalanche chute shrubland, Canadian Rockies

The Idaho Batholith. This ecoregion occupies a small portion of western Montana. It is partially glaciated and characterized by granitic mountains and deeply dissected valleys. Soils are derived from granites, and lack fertility. Vegetation is considerably drier than in surrounding ecoregions; Ponderosa pine and Douglas-fir are dominant,

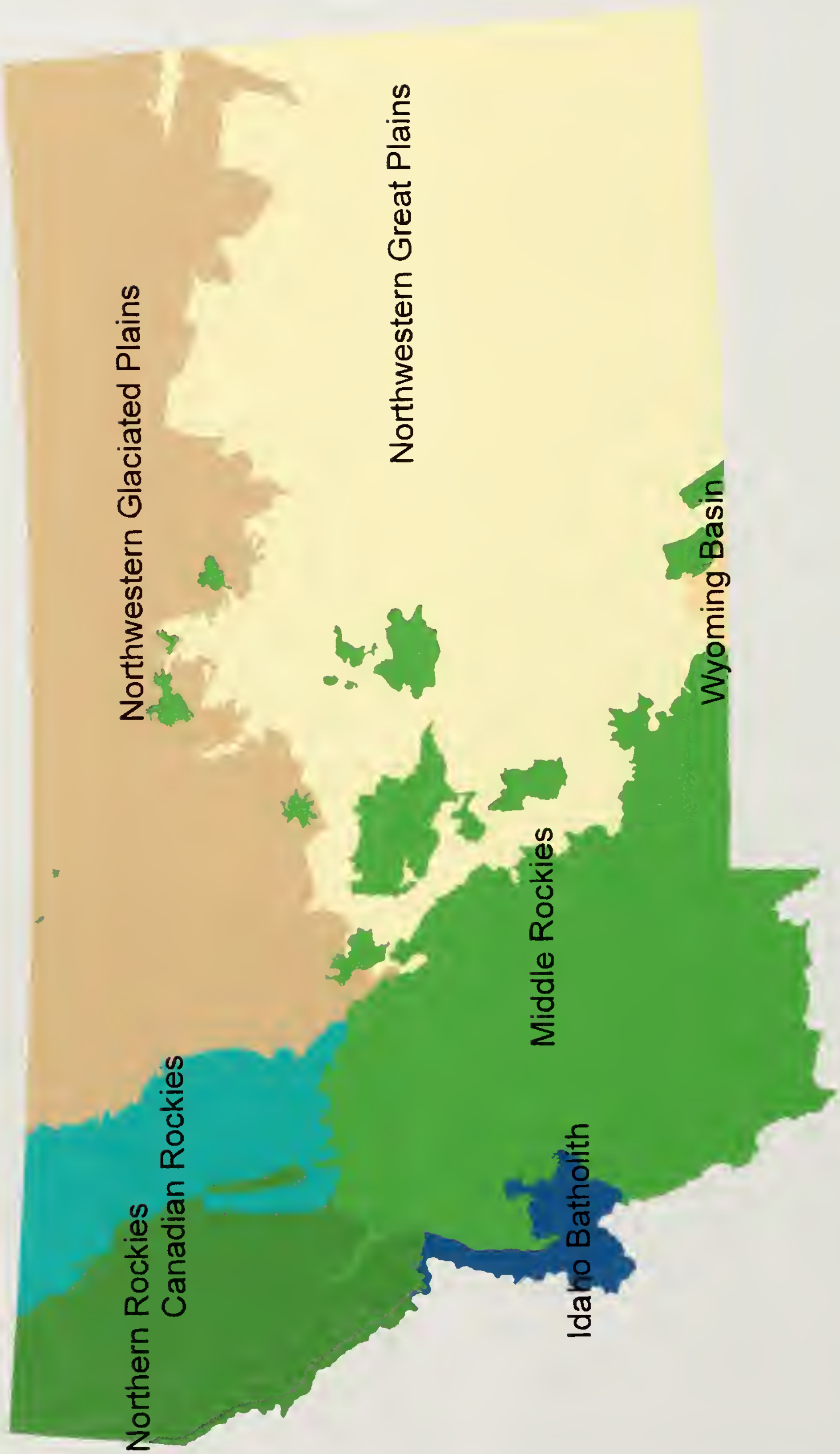

Figure 1. Level III Ecoregions


Figure 3. Ephemeral stream, Canadian Rockies

with subalpine fir at higher elevations. Wetlands are relatively uncommon, but include riparian woodlands and shrublands, avalanche chute shrublands, and beaver ponds. Vernal pools and beaver-created wetlands along intermittent channels (Figure 4) are the most likely example of isolated wetlands here. Ephemeral streams channel snowmelt and runoff from rock surfaces, and do not always connect to other streams, instead often losing flow over their course.


Figure 4. Shrub-dominated beaver pond, Idaho Batholith

The Middle Rockies. The Middle Rockies ecoregion lacks a strong maritime influence, producing more open forest canopies than are typical in the Northern Rockies and Canadian Rockies. Forests are usually Douglas-fir, subalpine fir, and Engelmann spruce forests, with Ponderosa pine at lower elevations. Foothills are either partially wooded, or shrub- and grass-covered, and broad, shrub or grass-covered intermountain valleys are frequent, usually in association with large river valleys. Wetlands occur with some frequency in the valleys, and include wet meadows, sloughs, oxbows, beaver ponds, riparian and floodplain shrub and forested wetlands, and emergent marshes (Figure 5). When groundwater tables are high, as in the valleys, almost any Palustrine wetland can occur in isolation from the main channel of streams or rivers. Ephemeral streams are mostly fed by snowmelt; they may join intermittent streams or lose flow before connecting with any other watercourse. In the island mountain ranges of Central Montana, strong convective thunderstorms during summer may cause these streams to flow.


Figure 5. Wet Meadow, Middle Rockies

The Northern Rockies. Like the Canadian Rockies ecoregion, this forested ecoregion is rugged and mountainous with a strong maritime influence, but elevations are lower, perennial ice and snow is less extensive, and glacial lakes are more infrequent. Flathead Lake exercises a strong temperature-modifying influence in the Flathead Valley. In forested areas, wetland types include wet meadows, fringe wetlands around lakes, beaver ponds, fens, riparian woodlands

and shrublands, conifer swamps, avalanche chute shrublands, and wooded vernal pools (Figure 6). In the valleys, wetland types include wet meadows, willow sloughs, oxbows, beaver ponds, riparian and floodplain shrub and forested wetlands, and emergent marshes. As is true in the Middle Rockies, almost any Palustrine wetland type can be geographically isolated from the main channel of streams or rivers, especially when hydrological modifications for agricultural or residential purposes are prevalent. In forested areas, fens, vernal pools, and avalanche chute shrublands are the most likely to be geographically isolated. Ephemeral streams generally flow in response to snowmelt and spring rains, but occasionally drain large wet meadows and fens during peak saturation (Figure 7).

Figure 6. Vernal pool, Northern Rockies

Figure 7. Sedge-dominated fen, Northern Rockies

The Northwestern Glaciated Plains. The ecoregion extends eastward from the Rocky Mountain Front across the northern third of Montana and into North Dakota. Rolling hills and level to gently rolling glacial till plains are underlain by soft marine shale, and studded with thousands of small, shallow potholes. The region is considered to be the most important breeding habitat for waterfowl in North America with production estimates ranging from 50% to 80% of the continent's main species (Batt et al. 1989). Prairie wetlands support a diverse assemblage of water dependent birds including several Montana Species of Concern. Floodplain wetlands occur along some of the larger rivers such as the Milk and Marias, and both freshwater and saline marshes occur with some frequency. However, the characteristic wetland type in this ecoregion -- and the type most likely to be geographically isolated -- is the prairie pothole. Ephemeral streams occur throughout this area, often in the broad coulees that drain alluvial flats, and sometimes connect potholes in isolated basins (Figure 8).

Figure 8. Intermittent stream channel, Northwestern Glaciated Plains

Northwestern Great Plains. The Northwestern Great Plains ecoregion consists largely of an unglaciated, semiarid, rolling plain interrupted by infrequent badlands, buttes, and shallow, dissected valleys formed by ephemeral and intermittent streams. Although there is some alfalfa farming in the larger river valleys, most of the land is

rangeland. Precipitation is low and erratic, and evapotranspiration is high. When wetlands occur, they are primarily the result of seepage from reservoirs or poor drainage caused by road berms, although there are occasional willow sloughs and greasewood flats, and some saline depressions. Along the major rivers, cottonwood forests are extensive, although many have lost hydrologic connectivity to their floodplains and are becoming decadent. In the eastern part of the state, green ash-dominated woody draws and ravines are common, often with ephemeral streams running through them (Figure 9). Because tributary streams are rarely perennial, most wetland types in this area (except those associated with large rivers) are geographically isolated.

Figure 9. Woody draw, Northwestern Great Plains

The Wyoming Basin. Most of this ecoregion in Montana occurs between the Beartooth Front and the Pryor Mountains. Because it is in the rain shadow of the Beartooth Range, it is one of the driest regions in the state, almost entirely dominated by sagebrush steppe and greasewood flats. Wetlands occur sporadically along the few perennial streams and rivers, and around springs and seeps. These spring-seep wetlands are often the headwaters of perennial tributaries to navigable waters (particularly the Bighorn River); the few that feed intermittent steams would be the most typical isolated type (Figure 10). During extreme precipitation events in May and June, fast-flowing ephemeral streams carve channels through the sandy valleys.

Figure 10. Isolated spring, Wyoming Basin

In our results section, we present our analyses by ecoregion. The reader is encouraged to refer back to these ecosystem descriptions as an aid in interpretation.

Methods

Identification and analysis of isolated wetlands and ephemeral streams required several GIS data layers, shown in Box 1. Methods for extracting each wetland grouping were as follows:

Geographically Isolated Wetlands

We used a series of data processing routines and subroutines to identify geographically isolated wetlands. We included only natural wetlands in this analysis, i.e. wetlands that were not drained, ditched, diked, impounded or excavated. This portion of the analysis was also restricted to Palustrine wetlands. Lacustrine wetlands are defined as occurring within or directly adjacent to lakes and ponds that are over 20 acres in size or more than 6 feet deep. Most lakes of this size have sportfish populations, and some support commercial waterborne recreation. Therefore, we thought it likely that wetlands abutting such lakes would be subjected to full jurisdictional analysis if Clean Water Act permits were sought. Similarly, Riverine wetlands occur, by definition, within an active stream channel, and while it is possible that such a wetland might be isolated – if it occurred, for example, in a frequently exposed part of an intermittent stream – we reasoned that this, too, would require a case-by-case determination. Our goal in this part of the analysis was to identify the number and character of wetlands that apparently have no connection whatsoever to navigable rivers or their tributaries, or to other "waters of the U.S." Therefore, we defined geographically isolated wetlands as those Palustrine wetlands meeting all the following tests: 1) not on a large river floodplain, defined as a 300 meter buffer on either side of the river; 2) more than 40 meters from any perennial or intermittent stream or river, whether or not that stream or river was a tributary of a navigable river;[14] 3) not connected to a wetland that was itself on a large river floodplain or within 40 meters of a perennial stream or river; 4) not within 40 meters of a large (>20 acre) lake or wetland with a perennial stream inflow or outflow; and 5) more than 20 meters from any ephemeral channel. Our tests for geographic isolation were intended to identify those wetlands that had no direct connection to navigable waters and were least likely to have a demonstrable significant nexus to navigable waters.

We began by creating a "Natural Palustrine Wetlands" GIS layer. At each stage of the analysis, we created a new attribute field in the layer, and added a "Y" if the wetland fell into the analytic category (e.g. with 300m of a large river, within 0, 20 or 40 meters of a perennial or intermittent stream or river, etc). When all proximity tests were exhausted, the remaining wetlands were given a "Y" notation as totally geographically isolated.

Adjacent Wetlands

We also wanted to identify the percentage of wetlands that were most likely to be considered jurisdictional, based on their adjacency to traditional navigable waters or their tributaries within the meaning of the Clean Water Act and the guidance. Therefore, during our analysis, we identified any wetlands that intersected a large river or were within its 300 meter buffer. We also identified "Riverine, lower perennial" wetlands with a water regime of "permanently flooded" or "semipermanently flooded." These wetlands are typically found within the active channel of large rivers, or of tributary streams and rivers having significant flow, and therefore "directly abut" such water bodies. Similarly, all Lacustrine wetlands that were part of a lake greater than 20 acres in size and all Palustrine wetlands

[14] Tiner et al. (2003) noted that the spatial accuracy of single-line digital representations of streams is often insufficient when it comes to capturing streamside wetlands through an intersection of those lines and NWI boundaries, and recommended 20 and 40 meter buffers of streamlines as a solution. We limited the buffer to 20 meters in the case of ephemeral and low-order channels, reasoning that only those wetlands more or less directly intersected by such a channel would ever be classified as jurisdictional. However, we used a 300 meter buffer for large rivers because our experience informs us that these rivers undergo significant channel migrations, and that a wetland that appears to be isolated on the margin of a floodplain in any given year may have been connected in the past and has the potential to be connected in the future. Moreover, because these large river floodplains have such high ecological significance in the semi-arid West, we believe that "significant nexus" could easily be established.

Box 1 - GIS Data Layers used in Analysis

1. National Wetlands Inventory (NWI) maps and data produced by the U.S. Fish and Wildlife Service in the 1980s and 1990s (1:24,000 resolution). These maps and data were not available in digital format for the entire state, so the analysis is restricted to areas with digital coverage. Where more recent maps were available from the NWI (e.g. for the Bitterroot Valley), these were used in place of the older version. The analysis covers all wetland data digitally available as of October 2008. Recent NWI mapping completed as part of this project will be analyzed separately, and results issued as an addendum.

2. The National Hydrography Dataset (NHD) high-resolution vector data from the United States Geological Survey (1:24,000 resolution) was used to identify basins, subbasins and watersheds (hydrologic units), as well as hydrography (streams, rivers, and waterbodies). This dataset is still being updated; the version used here was current in October 2008. Datasets were downloaded from the USGS site for each 4th code Hydrologic Unit containing mapped wetlands. Data extraction routines separated natural flowlines (stream and rivers) and separated them into perennial, intermittent and ephemeral categories. We used the NHD area coverage to identify large rivers (i.e. those rivers depicted as two-line features on topographic maps). Most of these rivers, or portions thereof, are navigable in fact by personal watercraft during part or all of the year, and have been or could be used for commercial waterborne recreation.

3. Ecoregion boundaries were drawn from GIS data downloaded from the EPA Western Ecology Division website (EPA, no date) established on a GIS layer obtained from the EPA .

4. USGS 1:24,000 topographic map boundaries, maintained by the Natural Resource Information Service (NRIS) were used in calculations and as a mapping framework.

5. The 30-meter National Elevation Dataset (NHD) was obtained from the United States Geological Survey and used to create a slope layer.

6. Management and ownership boundaries were drawn from the most recent MTNHP Stewardship layer, updated in 2008.

7. Relative Effective Annual Precipitation was provided by the Natural Resource Conservation Service (NRCS).

8. SSURGO Soils layers (1:24,000) from the Natural Resource Conservation Service (NRCS) were used as ancillary layers in mapping.

9. For verification of classification, and for mapping additional wetlands, we used National Agricultural Imagery Program (NAIP) color and color infrared aerial photographs from 2005.

All extraction and geoprocessing tasks were performed in ArcGIS 9.2 and 9.3 (ESRI 2007, 2008). Calculations of acreage were done with X-tools Pro version 5.2; all other calculations were carried out in Microsoft Excel.

that were within 40 meters of a large lake (>20 acres) were characterized as adjacent based on the assumption that lakes of this size are likely to have fishery or recreational value for interstate travelers as defined in 33 C.F.R. § 328.3(a)(3). Here too, we recognized that jurisdiction would have to be established on a case-by-case basis for some of these wetlands, but we believed that any such wetlands would be most likely to pass a "significant nexus" test.

Wetlands That May Have a "Significant Nexus" to Navigable Waters

Recognizing the greatest challenge for determinations of jurisdiction is posed by wetlands which are neither totally isolated nor associated with navigable rivers, other large rivers, or lakes, we drew out three key wetland classes from the dataset. From these, we created a tentative classification of "potentially non-isolated wetland." Any wetland that was directly intersected (using the 20m buffer) by a perennial or intermittent stream was assumed to be benefiting by either a permanent or stable surface water or groundwater connection. We assumed the same of any wetland classified as Upper Riverine in the NWI, or any Lower Riverine wetland having a temporary, seasonal or intermittent flooding regime. Based on our field observations throughout Montana, we reasoned such wetlands had a potentially "significant nexus" to a navigable stream or river during at least some part of the year. We also identified wetlands with 40 meters of another large (>20 acre) wetland that itself had a direct connection to a perennial stream or river. Again, this classification was based on observation and professional judgment; such wetlands are usually part of a wetland complex with high ecological value. Although we recognize that these "potentially non-isolated wetlands" would have to be evaluated in the field on a case-by-case basis to establish jurisdiction under the Clean Water Act, we felt it was useful to highlight them in the analysis.

Wetlands with Uncertain Classification

All other wetlands were classified as "uncertain." These include Palustrine wetlands occurring between 20 and 40 meters from a stream, wetlands within 20 meters of an ephemeral stream, and wetlands connected to or adjacent to small lakes. It may be possible in many or even most cases to establish a "significant nexus" based on factors observed in the field; however, to attempt such a determination through a GIS would be too speculative.

To test the accuracy of the "totally isolated wetland" classification, we selected a random sample of USGS quads containing the classified wetlands, overlaid the "totally isolated wetlands" layer on the NAIP imagery for those quads, and examined each classified wetland visually until 1% of the number of "totally isolated wetlands" in each ecoregion had been inspected. In all, 780 wetlands were visually inspected. Of these 780, 31 could not be found on the photographs, either because of land use change or protracted drought. The remaining 749 were all located and determined to have no surface water connection to any natural hydrographic feature. To further test our methods, we randomly chose an additional 125 totally isolated wetlands from a preliminary classification in 2007; from those, we selected a subset of 25 (5 in each of the Northern Rockies, Canadian Rockies, Middle Rockies, Northern Glaciated Plains and Northwestern Great Plains ecoregions) that were on public land and reasonably accessible. These were also inspected visually to ensure they still existed, and then were field verified.

Functions and Values of Isolated Wetlands

In addition to identifying the distribution and extent of isolated wetlands in Montana, we wanted to determine what wetland functions were associated with such wetlands. To accomplish this, we used an approach initially developed by Ralph Tiner of the U.S. Fish and Wildlife Service

(Tiner 2003, Tiner 2005), adapted by the Montana Natural Heritage Program in previous wetland analyses (Vance et al. 2006, Kudray and Schemm 2008). This approach assigns hydrogeomorphic attributes to wetlands based on landform, landscape position, water body type, and water path. Unlike true hydrogeomorphic assessments, which require site-specific field investigations, this method – termed the LLWW method by Tiner (2005) – can be implemented in the office with a GIS and aerial photos. Once hydrogeomorphic attributes are added to wetlands, they are combined with NWI attributes to yield a combination that can be ranked on a performance scale of 1 to 3 for each of ten functions (flood storage, groundwater recharge, streamflow maintenance, nutrient cycling, sediment retention, bank stabilization, terrestrial habitat, aquatic habitat, maintenance of native vegetation, and contribution to wetland biodiversity). A score of 3 indicates that wetlands with this combination of NWI attribute and LLWW code perform a given function at the highest level, relative to other wetlands. The method does not take wetland condition into account in assigning performance scores, but rather ranks potential based on presumed functioning condition.

Because of the sheer number of wetlands we were analyzing, we did not use aerial photos in assigning LLWW codes to wetlands. However, in the case of isolated wetlands, this was not especially significant, as visual inspection is primarily used to assign water path, and isolated wetlands, by definition, do not have a water path. Similarly, riverine wetlands and lacustrine wetlands can be assumed to have throughflow and bidirectional water flow paths, respectively. Wetlands on floodplains or surrounded by uplands, by contrast, can have one of four water paths; inflow, outflow, throughflow, or none. Because we had no way to determine the water path for these wetlands without inspecting each one individually, we assigned an outflow path as the default, as this is the most common flow path for non-isolated, non-riverine wetlands in floodplain or upland settings.

Wetlands within 40 meters of a lake were classified as lentic wetlands if they occurred on a slope of less than 4%. Wetlands on steep slopes were assumed to be discharging into the lake rather than benefiting from any bidirectional flow. These were classified as terrene wetlands. Riverine wetland gradients were classified as follows: > 4% = high gradient; > 2% =medium gradient; and <2%= low gradient. Terrene wetlands were classified as basin wetlands if they occurred on a slope of less than 4% and as slope wetlands if they occurred on a slope of greater than 4%. All slope classifications were derived from a 30m Digital Elevation Model produced by the USGS.

Ephemeral Streams

When this project was initially proposed, only medium-resolution National Hydrography Data (1:100,000) was available for most of Montana. This data did not capture many of the smaller intermittent and ephemeral streams. Our intention was to create a model allowing us to extend the drainage network visible on the 1:100,000 data to encompass these features, using the Arc Hydro tools (Center for Research in Water Resources 2003) that have since been incorporated into the Spatial Analyst toolbar in ArcGIS. The procedure we used involved several steps in either Arc Hydro or Arc GIS: 1) fill all surface irregularities in a 10-meter digital elevation model (DEM); 2) using that DEM, assign flow direction to each 10 x 10 meter cell; 3) for each 10 x 10 meter cell, calculate flow accumulation; 4) convert flow accumulation data in cell numbers to area in square meters, and take the natural log 10 of that to create drainage areas in order of magnitude; 5) use a conditional statement (CON tool or Spatial Analyst Raster Calculator) to identify all cells having a flow accumulation area of 105 m^2 (10 hectares) in the Canadian Rockies, Middle Rockies, and Northern Rockies Ecoregions, or 106 m^2 (100 hectares) in the Northwestern Great Plains, Northwestern Glaciated Plains and Wyoming Basin. This step generates a stream grid; 6) calculate Strahler stream order for each segment of the grid; and 7) use a conditional statement to identify all 1st and 2nd order streams.

NHD PLUS (Horizon Systems 2006) is a value-added version of the 1:100,000 NHD, and includes both stream order and accumulation values for all stream segments. We buffered 1st and 2nd order streams from NHD PLUS by 50 meters,

converted our 10m DEM-based grid of 1st and 2nd order streams into polylines, and selected out all lines that were within the 50 meter buffer of the NHD PLUS 1st and 2nd order streams, assuming these modeled streams to be occupying the same geographic space that the NHD digitized streams do. The remaining modeled polylines were identified as small, intermittent or ephemeral streams. This portion of the analysis was completed for several randomly selected 4th code hydrologic units in late 2006, and modeled streams were examined on NAIP imagery before a sample was selected for field verification. Shortly thereafter, the high-resolution NHD became available. When we compared our modeled ephemeral/intermittent stream layer to the 1:24,000 NHD, we found our polylines generally overlapped (or were within 50 meters of) digitized lines. Repeating step 5 above with a smaller drainage areas (1 to 5 hectares in the western mountain ecoregions and 10 to 50 hectares in the plains ecoregions) area generated additional modeled stream channels, but inspection of NAIP imagery indicated few, if any, of the modeled channels existed on the ground.

With the two NHDs at different resolutions, we were able to create a simple model for identifying very low-flow intermittent and ephemeral streams. As noted earlier, the NHD was digitized from topographic maps that were themselves created through aerial photo interpretation at differing scales. Each reach segment in the NHD is assigned a unique reach code; whenever a segment is added, it gets a new code. Therefore, by joining attribute tables from the medium resolution NHD to the high-resolution NHD, and selecting all high-resolution reaches having no medium resolution counterpart in the joined table, we created a layer of stream features only present at the 1:24,000 scale. These were assumed to be the smallest detectable stream features (i.e. very low-flow intermittent and ephemeral streams).

Results

Geographically Isolated Wetlands

NWI Wetland mapping is incomplete for most of Montana. By ecoregion, the percentage of mapped USGS 24K quads ranges from a high of 94% in the Northern Glaciated Plains to a low of 0% in the Wyoming Basin (Table 1). Because of this, the analysis may not accurately capture the number and percentage of isolated wetlands in the Idaho Batholith, the Northwestern Great Plains and the Wyoming Basin.

Table 1. Percentage of 24K USGS quads with wetland mapping, by ecoregion

Canadian Rockies	72%
Idaho Batholith	36%
Middle Rockies	30%
Northwestern Great Plains	12%
Northwestern Glaciated Plains	94%
Northern Rockies	35%
Wyoming Basin	0%

Nevertheless, the analysis reveals a stark figure: of 252,186 natural wetlands currently mapped in Montana, 152,726 -- 61% of all wetlands -- have no visible surface water connection to any other water body.[15] When only Palustrine wetlands are considered, 65% of wetlands across the statewide mapped areas are isolated. Table 2 shows the number of mapped wetlands, the number of mapped Palustrine wetlands, and the number of geographically isolated wetlands by ecoregion.

In terms of wetland acreage, the percentages are lower, simply because geographically isolated wetlands are typically small. Mapped wetlands in Montana cover some 735,338 acres; of this total, 491,566 acres are Palustrine, and 176,224 acres are geographically isolated. Even in the Northwestern Glaciated Plains, where 50% of Palustrine wetlands are geographically isolated, only 30% of the total Palustrine acreage is isolated. Isolated wetlands are generally less than half the average size of all Palustrine wetlands.

Palustrine emergent wetlands (Cowardin class PEM) account for 91% of isolated wetlands. Isolated PEM wetlands characteristically have a short inundation period; 93% of those identified in this analysis are classified as having either a seasonally flooded or a temporarily flooded water regime. In the Northwestern Glaciated Plains (better known as the prairie pothole region), where poorly-defined or non-existent surface drainage channels are a characteristic of the rolling landscape, fine-textured, low-permeability soils limit infiltration (Winter 1989), and small drainage basins concentrate even the small amount and low velocity of surface runoff. Rainfall accumulates rapidly in potholes during spring months, especially when soil frost is sufficiently deep to forestall all infiltration until after the ground thaws. With frozen ground producing virtually impermeable soils, springtime rains and

Table 2. Mapped, palustrine and isolated wetlands, by ecoregion

Ecoregion	All mapped	Palustrine	Isolated
Canadian Rockies	15495	12211	5138
Idaho Batholith	1214	840	339
Middle Rockies	39980	35060	14959
Northwestern Great Plains	7430	5789	2436
Northwestern Glaciated Plains	169384	163052	118131
Northern Rockies	18683	17657	11723
Wyoming Basin	0	0	0

[15] In the Northwestern Glaciated Plains, surface water connections may occur sporadically when periods of intense rain result in potholes overflowing and forming temporary connections to adjacent ones, a phenomenon Leibowitz and Vining (2003) term "temporal connectivity." However, even though they characterize this connectivity not as a presence-absence occurrence, but rather as "a probability event with some distribution over time and space," no channelization occurs, and so no traces can be seen on aerial photographs. Moreover, the gentle, rolling topography of the area is not easily captured on 10m digital elevation models (the best commonly available), so drainage paths cannot even be predicted with hydrography models.

runoff produce far higher surface water levels than summer rain and runoff events (Winter 1989). In summer, evapotranspiration is the primary conduit for water loss (Shjeflo 1968), generally exceeding precipitation during summer months.

The same clay and silts limiting infiltration when wet are prone to developing secondary cracks during dry months, resulting in rapid infiltration when summer rain events occur. Consequently, isolated potholes will be relatively dry throughout most years, and only hold measurable amounts of water in years when precipitation significantly exceeds average. Small, closed depressional wetlands can also be found in other parts of the state where low-permeability soils are common (Figure 11).

Figure 11. Closed depressional wetland, Northwestern Great Plains

Palustrine aquatic bed (PAB) wetlands account for the next largest group of isolated wetlands in this study (5% of the total number), although Palustrine shrub-scrub wetlands form the second largest class when acreage is considered. Shrub-scrub wetlands and forested wetlands tend to be the largest isolated wetlands by size, averaging around 1.75 acres. These wetlands are often found in old oxbows and cutoffs, or around springs and seeps with insufficient volume to form channels.

Although wetlands on private land are often in very good condition, and regarded by their private owners as assets requiring careful stewardship, changing economic and demographic factors frequently drive land transfers or leases, resulting in altered management practices. Similarly, state lands held in trust (so-called "school lands") are subject to leasing, and are often valued for their oil, gas and mineral potential. Tables 3 and 4 show the ownership of isolated wetlands.

While it appears wetlands in the Northwestern Great Plains have extremely high private and state ownership, we caution the reader may not be entirely true, given that only a small part of the ecoregion has NWI maps. However, 72% of the acreage in the ecoregion as a whole is privately owned without conservation easements, and 6% is state trust land, so there may be a higher percentage of wetlands in these ownership classes in this ecoregion than in, say, the Canadian Rockies, much of which is owned by the federal government.

Table 3. Isolated wetlands on private lands without conservation easements

Ecoregion	Privately owned, by number	Privately owned, in acres	Percent of isolated wetlands	Percent of isolated wetland acres
Canadian Rockies	587	567	0	0
Idaho Batholith	82	85	0	0
Middle Rockies	5756	6115	4	3
Northwestern Great Plains	1743	1383	1	1
Northwestern Glaciated Plains	73047	92007	48	52
Northern Rockies	5667	4995	4	3
Wyoming Basin	0	0	0	0

Table 4. Isolated wetlands on state trust land

	State trust land, by number	State trust land, in acres	Percent of isolated wetlands	Percent of isolated wetland acres
Canadian Rockies	58	41	0	0
Idaho Batholith	0	0	0	0
Middle Rockies	808	1038	1	1
Northwestern Great Plains	128	97	0	0
Northwestern Glaciated Plains	9311	10698	6	6
Northern Rockies	313	446	0	0
Wyoming Basin	0	0	0	0

We also note for purposes of this analysis, reservation lands are considered to be under public stewardship, even when individual parcels on the reservation are privately held.

Wetlands Associated with Navigable Rivers or Large Lakes

Montana is a semi-arid state, but has several major rivers (Figure 12).[16] For this portion of the analysis, we sought to identify wetlands that would almost certainly fall within the ACOE/EPA guidance: Riverine wetlands mapped as "lower perennial" with permanent or semi-permanent water regimes (Lower Perennial Flooded Riverine.shp), contained within or immediately adjacent to, rivers drawn as two-line features on USGS 1:24,000 maps. We also included Lacustrine wetlands and Palustrine wetlands adjacent to lakes greater than 20 acres in size, since these lakes are likely to have fishery, waterfowl/wildlife habitat or recreational value that would bring them under the ACOE's regulation 33 C.F.R. §328.3(a) that includes "(3)...intrastate lakes...(i) which are or could be used by interstate or foreign travelers for recreational or other purposes" the use, degradation or destruction of which could affect interstate commerce;... [and] (7) wetlands adjacent to [those] waters."[17]

This analysis demonstrates how few mapped wetlands clearly meet the tests laid down in the *Rapanos* decision. Only 14,691 wetlands (out of the statewide mapped total of 252,186 wetlands) fall within 300 meters of a large river. Including lower perennial Riverine wetlands with permanent or semi-permanent water regimes adds an additional 1,114 cases. A further 3,509 mapped wetlands are Lacustrine wetlands associated with a large lake or Palustrine wetlands within 40 meters of such a lake. In short, only 19,314 mapped wetlands in Montana -- less than 8% of the total -- are associated with navigable rivers or large lakes or have a continuous surface water connection to other large rivers. Tables 5 and 6 give a breakdown of these wetlands by ecoregion.

[16] The state has declared that several Montana rivers are navigable in the document titled **Water ways owned by the State of Montana and Administered by the Department of Natural Resources and Conservation Trust Land Management Division**. These include the Clark Fork, Beaverhead, Big Hole, Bighorn, Bitterroot, Blackfoot, Dearborn, Gallatin, Flathead, Jefferson, Judith, Kootenai, Madison, Marias, Middle Fork Flathead, Missouri, North Fork Blackfoot, North Fork Flathead, Smith, South Fork Flathead, Sun, Tongue, Yaak and Yellowstone Rivers, plus Lake and Rock Creeks. We have defined all two-line rivers as navigable, thus bringing such rivers as the Milk and Musselshell into the analysis, as well as other rivers that are floatable with personal watercraft and subject to commercial use for recreation.

[17] Again, this interpretation could be broadened. The same subsection refers to "rivers, streams (including intermittent streams, mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes or natural ponds" that might affect interstate commerce if degraded or destroyed. Arguably, any stream or river regularly visited by out-of-state fishermen (e.g. the Shields, Stillwater, Swan, Clearwater etc) and any wetland or pothole complex known to draw out-of-state waterfowl hunters could be considered a "water of the United States" under these regulations. Whether a water body that meets the interstate commerce criterion must also meet a "significant nexus" test remains unclear. Consequently, we limited the analysis to the cases described above.

Figure 12. Montana ecoregions and large rivers

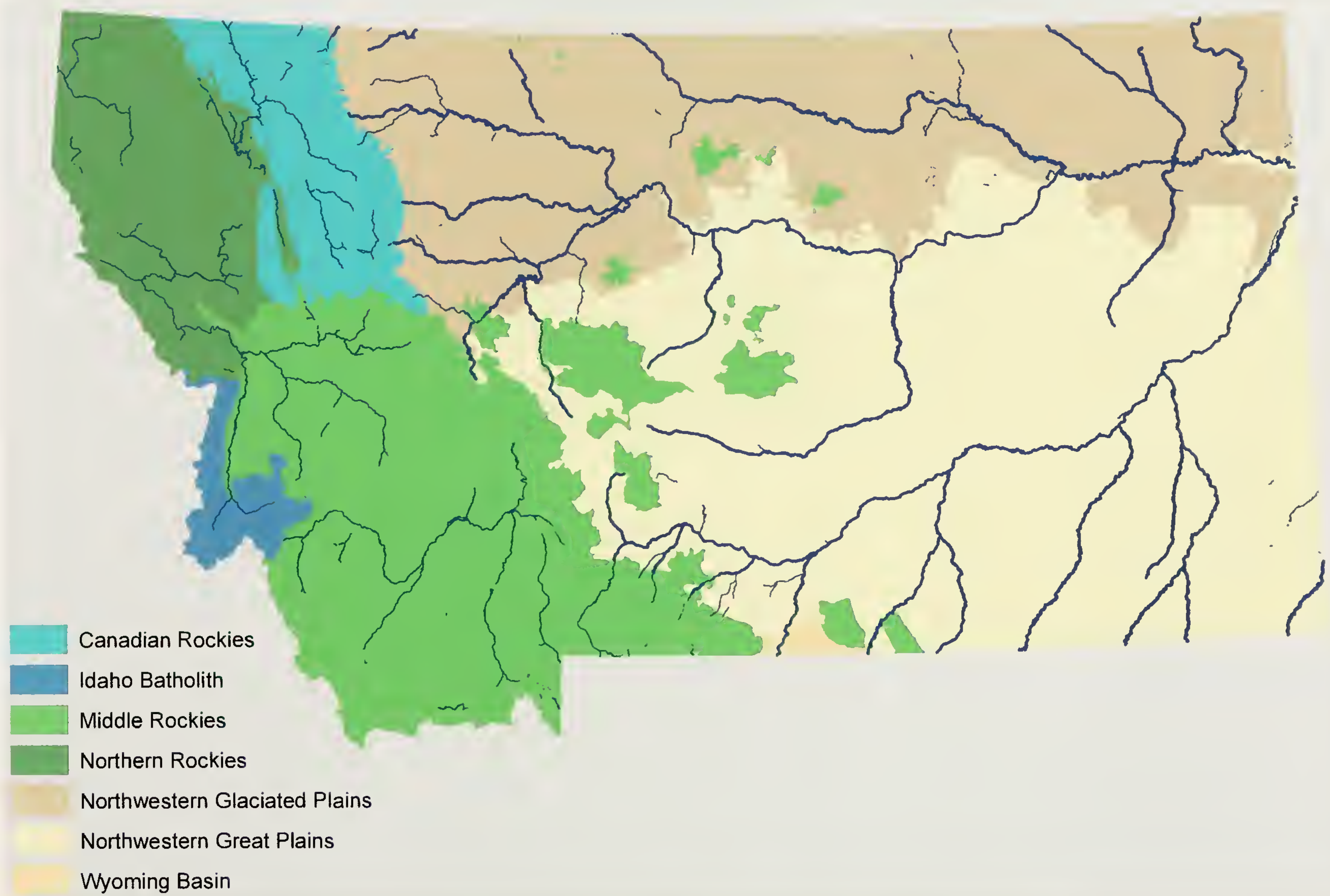

Table 5. Wetlands within 300m of a large river, and "riverine, lower perennial wetlands" with permanent or semipermanent water regimes

Ecoregion	Number within 300m of a large river	Acres within 300m of a large river	Number of lower perennial with permanent or semi-permanent flooding	Acres of lower perennial with permanent or semi-permanent flooding
Canadian Rockies	888	3301	2	11
Idaho Batholith	176	136	0	0
Middle Rockies	5793	23336	148	6436
Northwestern Great Plains	1179	4211	125	10090
Northwestern Glaciated Plains	5118	26810	818	36489
Northern Rockies	1537	6227	21	6591
Wyoming Basin	0	0	0	0

Table 6. Lacustrine wetlands and Palustrine wetlands within 40 meters of a lake greater than 20 acres in size

Ecoregion	Number within 40m	Acres within 40m
Canadian Rockies	433	37680
Idaho Batholith	28	1410
Middle Rockies	472	48925
Northwestern Great Plains	162	223599
Northwestern Glaciated Plains	1959	140428
Northern Rockies	455	150826
Wyoming Basin	0	0

Wetlands That May Have a "Significant Nexus" to Navigable Waters

Although the conclusions drawn in this part of the analysis are more speculative than those for totally isolated wetlands or wetlands associated with large rivers and lakes, we thought it useful to identify wetlands most likely to have a "significant nexus" to waters of the United States, based on available data and considering current interpretations of the *Rapanos* decision. We defined these wetlands as those within 20 meters of a non-navigable but perennial stream,[18] and wetlands with 40 meters of another large (>20 acres) wetland that has a direct connection to a perennial stream or river. Based on field observations, we felt such wetlands typically have the kind of hydrological, biological or chemical connection to navigable waters or their immediate tributaries that meets the "significant nexus" test. It was not our goal here to identify specific wetlands and assign tentative jurisdictional claims to them; rather, we wanted to get a sense of their extent in both numbers and acreage.

This analysis identified 31,196 wetlands -- almost 13% of all mapped natural wetlands -- within 20 meters of perennial streams. Of those, 14,527 were Riverine wetlands, defined in the Cowardin system as wetlands within the active channel of a river. Wetland acreage totaled 145,145 acres across all wetland types, or 19.7% of all mapped natural wetland acreage. 65% of these Palustrine wetlands and 55% of the Riverine wetlands were in the Canadian Rockies, Idaho Batholith, Middle Rockies or Northern Rockies ecoregions, characteristically the wettest areas of the state with the largest concentration of perennial streams.[19]

[18] We used a 20 meter buffer rather than a direct intersection to account for spatial inaccuracy in the depiction of wetlands in the NWI.

[19] Of course, these percentages would be higher if more of the wetlands in these ecoregions were mapped.

An additional 327 wetlands (1,521 acres) were within 40 meters of other large wetlands (>20 acres).[20] Large wetland complexes are important ecological resources, especially in semi-arid environments, acting as critical habitats and corridors for wildlife. Depending on their landscape position, these complexes will often have an evident nexus to the biological, chemical, and ecological health of traditional navigable waters.

Wetlands with Uncertain Classification

Almost 20% of mapped wetlands in Montana -- 48,623 -- are of uncertain classification. These are the wetlands our GIS analysis indicates are neither geographically isolated nor sufficiently close to permanent water to warrant a classification of probable Clean Water Act jurisdiction. In general, they include:

- wetlands adjacent to intermittent streams,
- wetlands more than 20 meters from a non-navigable perennial stream or river,
- wetlands associated with small lakes or ponds,
- wetlands near other small wetlands or near large wetlands with no perennial stream associated with them;
- wetlands near springs and seeps that are not part of a perennial stream

Of course, any of these wetlands may fall under the jurisdiction of the Clean Water Act if the Army Corps of Engineers or the Environmental Protection Agency determines there is a "significant nexus" with a traditionally navigable water based on the flow characteristics and function of the perennial or intermittent stream with which the wetland is associated. Similarly, neither this nor any other GIS analysis can be taken as a definitive statement of jurisdiction. In the absence of a clear legislative move by the state or federal government to bring all wetlands under a single jurisdictional umbrella, jurisdictional determinations will almost always require case-by-case scrutiny.

Functions and Values of Isolated Wetlands

To assess the functions and ecosystem values of isolated wetlands, we analyzed the landscape position, landform, water body and water flow paths for each wetland. This analysis resulted in 54 combinations of NWI attributes and LLWW attributes for isolated wetlands. The combinations and relative scores for each function are in Table 7. In general, we used the same scores as were assigned by Kudray and Schemm (2007) in their study of Bitterroot Valley wetlands. When we had wetland combinations not assigned scores in that study, we assigned scores based on professional judgment and literature reviews. In several cases, we took the fact of isolation into account when ranking attributes. In particular, we gave higher habitat, biodiversity, and native plant community ranks to Palustrine forested wetlands, and to all wetlands with a saturated ("B" in the Cowardin system) water regime. Palustrine forested wetlands are uncommon in Montana, and isolated ones less common still; because of the additional moisture provided by seasonal or temporary flooding, these wetlands tend to have high plant species richness. Saturated conditions often indicate the presence of fens or karrs, especially when coupled with isolation; both of these wetland types often have high biodiversity and support endemic species. Similarly, beavers are increasingly uncommon throughout the Rocky Mountains, so we gave wetlands with a "b" modifier a higher ranking on aquatic habitat and wetland biodiversity functions. However, because beaver activity tends to flood uplands and drown terrestrial vegetation, we did not change the values assigned for native plant community maintenance or terrestrial habitat.

Our rankings align with several recent studies describing the functions and values of isolated wetlands; they perform all wetland functions, and in some cases perform as well or better than their non-isolated counterparts. In this section, we discuss each function individually.

[20] This figures includes only wetlands that did not also fall into some other category (e.g. within 20m of a perennial streams, on a large river floodplain, etc).

Table 7. Isolated wetlands and functional performance ranks

NWI Attribute	LLWW Attribute	Acres	Flood Storage	Groundwater Recharge	Streamflow Maintenance	Nutrient Cycling	Sediment Retention	Bank Stabilization	Terrestrial Habitat	Aquatic Habitat	Native Vegetation	Wetland Biodiversity
PABF	TEBAIS	2587.37	2	2	2	1	2	3	1	3	2	2
PABFb	TEBAIS	4.86	2	2	2	1	2	3	1	3	2	2
PABG	TEBAIS	3525.05	2	2	2	1	2	3	1	3	2	2
PABGb	TEBAIS	623.56	3	2	2	1	1	3	1	3	2	2
PABH	TEBAIS	9.54	2	2	2	1	2	3	1	3	2	2
PEMA	TEBAIS	35019.24	1	2	2	2	2	3	3	3	1	2
PEMA	TESLIS	816.68	3	3	2	2	2	3	3	3	1	1
PEMAb	TEBAIS	2.76	1	2	1	3	2	3	3	3	2	3
PEMB	TEBAIS	4563.31	2	3	2	1	2	3	3	3	3	3
PEMB	TESLIS	2740.35	2	2	3	1	2	3	3	3	3	3
PEMBb	TESLIS	0.45	3	3	2	2	3	3	3	3	3	3
PEMC	TEBAIS	20258.93	1	1	3	1	2	3	2	3	2	3
PEMC	TESLIS	2317.00	1	1	3	1	2	3	2	3	2	3
PEMCb	TEBAIS	39.40	2	2	2	2	2	3	2	3	2	3
PEMCb	TESLIS	6.94	2	2	2	2	2	3	2	3	2	3
PEMF	TEBAIS	2757.07	2	2	3	1	2	3	1	3	3	2
PEMF	TESLIS	207.88	1	2	3	1	1	2	1	3	3	2
PEMFb	TEBAIS	15.97	2	2	1	2	2	2	2	3	3	3
PEMFb	TESLIS	5.82	2	2	1	2	2	2	2	3	3	3
PEMG	TEBAIS	1.10	1	2	1	1	2	2	2	1	1	3
PFOA	TEBAIS	432.43	3	1	2	2	2	1	3	1	2	3
PFOA	TESLIS	70.49	3	1	2	2	2	1	3	1	2	3
PFOB	TEBAIS	163.04	2	2	2	3	3	2	3	2	3	3
PFOB	TESLIS	124.71	2	2	2	3	3	2	3	2	3	3
PFOBb	TESLIS	0.44	2	2	2	1	3	2	2	2	1	3
PFOC	TEBAIS	17.15	3	2	2	3	3	2	2	2	3	3
PFOC	TESLIS	5.39	3	2	2	3	3	2	2	2	3	3
PFOCb	TEBAIS	1.59	3	2	2	3	3	2	2	2	3	3
PFOFb	TESLIS	10.09	3	2	2	2	2	2	3	2	1	3
PSS	TESLIS	0.15	3	1	3	2	2	3	3	3	3	3
PSSA	TEBAIS	1632.80	3	2	3	2	2	3	1	3	2	3
PSSA	TESLIS	546.45	3	2	3	2	2	3	1	3	2	3
PSSAb	TEBAIS	4.44	3	2	3	2	2	2	2	3	2	3
PSSAb	TESLIS	0.64	3	2	3	2	3	2	2	3	2	3
PSSB	TEBAIS	860.06	2	1	3	1	3	3	3	3	3	1
PSSB	TESLIS	596.56	2	1	3	1	3	3	3	3	3	1
PSSBb	TEBAIS	8.04	2	1	3	1	3	3	3	3	2	3
PSSBb	TESLIS	17.94	2	1	3	1	2	3	3	3	2	3
PSSC	TEBAIS	1297.12	1	1	3	1	2	3	2	3	2	3
PSSC	TESLIS	177.58	1	1	3	1	2	3	1	3	2	3
PSSCb	TEBAIS	62.74	3	2	2	3	3	3	3	2	2	3
PSSCb	TESLIS	8.80	3	2	2	3	3	3	3	2	2	3
PSSF	TEBAIS	1.52	3	2	2	3	3	3	2	2	2	2
PSSFb	TEBAIS	1.07	3	2	2	3	3	3	3	2	2	2
PUBF	TEBAIS	16.82	2	2	3	1	2	3	2	2	3	3
PUBG	TEBAIS	27.32	2	2	2	1	2	3	2	1	3	3
PUBH	TEBAIS	96.70	2	3	3	1	2	3	2	2	3	3
PUBHb	TEBAIS	1.02	2	3	3	1	2	3	2	2	3	3
PUSA	TEBAIS	1240.17	1	2	3	2	2	3	2	2	3	3
PUSA	TESLIS	27.83	1	2	3	2	2	3	2	2	3	3
PUSB	TEBAIS	53.58	2	1	3	1	2	3	2	3	1	1
PUSB	TESLIS	2.22	2	1	3	1	2	3	2	3	1	1
PUSC	TEBAIS	625.63	1	2	3	2	2	3	2	2	3	3
PUSC	TESLIS	51.09	1	2	3	2	2	3	2	2	3	3
Grand Total		83686.92										

Flood Storage

In Montana, as in much of the west, stream and river hydrology is driven in large part by snowmelt. In the rolling terrain of the Northwestern Glaciated Plains, most of the winter's snow reaches streams through groundwater conduits and overland flow, often intensified by heavy rains falling on saturated ground in May and June. In the mountains and foothills, snowmelt -- often intensified by rain-on-snow events in late spring -- is channeled into the major drainages by ephemeral and intermittent streams, overland flow, and local flooding of headwater lakes. Wetlands trap and retain precipitation and runoff, desynchronizing inputs to streams, which in turn helps attenuate peak flows (Leibowitz and Nadeau 2003). Of course, performance depends on available storage capacity, suggesting large wetlands will perform this function better than small ones. As noted earlier, isolated wetlands tend to be smaller than non-isolated wetlands; however, many isolated wetlands occur as part of a larger landscape mosaic. Prairie potholes are the prime example; although small, they are numerous. Leibowitz and Vining (2003) note that the lack of visible surface-water connections between prairie pothole wetlands is an indicator they have sufficient collective capacity to retain flood waters under most conditions. Adamus et al. (1991) made a similar observation about all wetlands lacking outlets; they are generally more likely to trap flood flows than wetlands with throughflow hydrology. Wetlands with dense ground cover, such as forested and shrub-scrub wetlands, also have a high capacity for reducing peak flows (Klimas et al. 2004).

Of the 54 isolated wetland types in this study, 15 performed this function at the highest level (3), 24 were at the moderate level, and 15 were at the lowest level (1). Two of the wetland types ranked lowest in this category, PEMA-TEBAIS and PEMC-TEBAIS, also had the highest acreage among all isolated wetlands (35,019 and 20,259 acres respectively). As noted above, many of these types occur in large pothole complexes, and while individual pothole wetlands do not have large flood storage capacity, the complex as a whole does.

Streamflow Maintenance

Although not all wetlands support dry season flows (Bullock and Acreman 2003), wetlands with sparse, low-growing vegetation, wetlands on alluvial soils, wetlands in fine-textured or clay soils, and floodplain wetlands are most likely to perform well in this capacity. Our definition of isolation excluded all wetlands within 300 meters of large rivers, so few, if any, of the isolated wetlands in our study occur on floodplains. However, isolated wetlands are often characterized by sparse, low-growing vegetation, in part due to the same climatic and geologic factors contributing to their isolation.

Twenty-five of our 54 isolated wetland types ranked high on the streamflow maintenance function; 25 ranked moderate, and three ranked low.

Groundwater Recharge

Wetlands recharge groundwater by retaining surface flows and precipitation collected during wet periods and releasing this water to the ground by infiltration. A review by Bullock and Acreman (2003) noted that wetlands on floodplains or in isolated depressions were the most likely to recharge groundwater. In Montana, fens are a notable example of isolated wetlands with high recharge capacity.

Fens typically occur where groundwater discharges to the surface, either because of the substrate (fens are most common in calcareous areas) or the surrounding landforms (fens are common on slopes and especially along mountain-to-valley transitions). They are characteristically saturated throughout the growing season, and slowly recharge their own groundwater source during drying periods (Bedford and Godwin 2003). Prairie potholes also have complex discharge and recharge relationships with groundwater (Tiner 2003), although their typically brief inundation period tempers their performance for this function.

In this study, 5 wetland types were rated high on this function, 36 rated moderate, and 13 were rated low.

Nutrient Cycling

Wetland biogeochemical functions strongly influence water quality through nutrient cycling, sediment retention, and shoreline stabilization. Wetlands are well known for their ability to filter phosphate-laden sediments and to remove and retain nitrates through plant uptake; in urban areas, they are often constructed as part of riparian buffers designed to reduce non-point source pollution (Walker and Shannon 2006).

Wetlands with fluctuating water levels are best able to recycle nitrates and other nutrients (Tiner 2003); wetlands with semipermanent or permanent flooding regimes are generally more effective than drier wetlands, in part because they tend to have high levels of soil organic content (Tiner 2003). Effectiveness in nutrient cycling also depends on landscape position, since wetlands higher in the landscape receive less runoff, and by extension, fewer nutrient inputs. Consequently, wetlands best performing this function will generally be low on the landscape, and often near floodplains, and will have high soil organic matter, and dense herbaceous and woody vegetation (Hauer et al. 2002)

Nevertheless, we did not follow the example of Kudray and Schemm (2007) and apply elevation modifiers while assigning wetland functions in this study. Their study focused on a limited geographic area with more geologic and climatic uniformity. This study, by contrast, covers the entire state. "Lower" and "higher" in the landscape correspond to dramatically different elevation ranges in the Beartooths, for example, than in the Powder River Basin, and while there is ample evidence to support the idea that elevation matters in mountain-and-valley contexts, there is little documentation for the Great Plains. Therefore, we did not incorporate any elevation modifiers into our analysis.

Only ten isolated wetland attribute combinations scored high on this function; 19 ranked moderate, and 25 ranked low.

Sediment Retention

Wetland vegetation traps sediments, and thus improves downstream water quality (Tiner 2003). This is especially significant in areas with high road density, large amounts of crop agriculture, severe forest fires, or other surface-disrupting activities and events. Vegetated wetlands trap sediments better than non-vegetated types (Tiner 2003), so that forested, shrub-scrub and emergent vegetation types will be more likely to trap sediments than aquatic bed wetlands. However, isolated basin wetlands, vegetated or not, should be particularly effective in this regard, because they do not have an outlet to downstream waters.

Fifteen of our wetland types ranked high on this function; 37 had a moderate rank, and only 2 ranked low.

Shoreline Stabilization

Generally speaking, shoreline stabilization functions are most important in lakes and rivers where wind, currents, and seasonal flooding can erode shorelines and banks, thus increasing sediment and nutrient flows to downstream areas. Thick emergent wetlands stabilize lakeshores; in a similar fashion, woody and shrubby vegetation along streambanks protects them against bank collapse. Isolated wetlands can score high on this function because of their vegetation, but because they do not contribute to downstream water bodies, in a broader ecological context, the value of this function is small.

Most of the isolated wetlands in this study were types with good shoreline stabilization capacity. Thirty-nine ranked high, 13 were moderate, and only 2 ranked low.

Maintenance of Native Plant Communities

In the semi-arid West, where wetlands are relatively scarce, their habitat value is disproportionate to their extent. This function refers to the wetland's capacity to sustain a native plant community appropriate to the wetland's type. In Montana, emergent wetlands with brief flooding regimes are often dominated by non-natives. By contrast, wetlands with wetter water regimes, and wetlands dominated by shrubs and trees are more likely to harbor native species. Saturated

wetlands, whether emergent or shrub, are the least likely to be dominated by non-natives; the constant moisture favors specialized species adapted to wet environments.

Because isolated wetlands are, by definition, surrounded by uplands dominated by terrestrial plant species, they are especially vulnerable to invasion by moisture-loving non-native herbaceous plants. Therefore, although 23 isolated wetland types ranked high on this function and 24 ranked moderate, the 7 low-ranked wetland types account for over 40% isolated wetland acres.

Terrestrial Habitat

In the Intermountain West, wetland and riparian habitats are used by more than 140 species of wetland-dependent and wetland-associated birds, 30 species of mammals, and 30 species of reptiles (Gammonley 2004). Prairie potholes, the most common isolated wetland type in our study, are especially important. Across the pothole region, they are estimated to support from 50% to 80% of the continent's waterfowl production (Batt et al. 1989). In addition to waterfowl, prairie wetlands support a diverse assemblage of water-dependent birds, including several Montana Species of Concern.[21] The flooding and drying cycles common to pothole wetlands, and variability in water regimes between individual potholes both provide spatial and temporal habitat diversity that supports a range of bird, mammal and invertebrate species (Kantrud et al. 1989; Euliss et al. 1999). By contrast, fens, with their permanently saturated hydrology, provide moist habitat through the season, often within a dry upland landscape, and are often heavily used by mammal species ranging from shrews and voles to moose and grizzly bears. Rocky Mountain vernal pools offer similar habitat values to both bird and mammal species.

We ranked 19 of the 54 isolated wetland types as high performers on this function. Twenty-five were ranked as moderate, and 10 -- mostly flooded types -- were ranked low.

Aquatic Habitat

Although isolated wetlands do not typically support fish species, they provide critical habitat for amphibians. Indeed, the absence of fish elevates the overall habitat value of isolated wetlands, particularly if other important site factors (interspersion of open water and vegetation, stable water levels during amphibian spawning and hatching, etc.) are present (Sheldon et al. 2003). Prairie potholes provide habitat for several Montana Species of Concern, including the northern leopard frog (*Rana pipiens*), plains spadefoot toad (*Spea bombifrons*), and Great Plains toad (*Bufo cognatus*). The western hognose snake (*Heterodon nasicus*), although not directly dependent on wetlands, feeds on toads, which are dependent on standing water for at least part of their lifecycle. Similarly, wooded vernal pools, isolated beaver ponds, fens and marshes support breeding and rearing for Species of Concern western toads (*Bufo boreas*) and northern leopard frogs, and may be significant parts of the habitat matrix used by Coeur d'Alene salamanders (*Plethadon idahoensis*) and Idaho giant salamanders (*Dicamptodon aterrimus*). And, like non-isolated wetlands, isolated wetlands provide important habitat for a wide range of aquatic invertebrates.

Isolated wetlands in our study were recognized as having significant aquatic habitat values: thirty-two ranked high; 18 ranked moderate; and 4 were ranked as low.

Conservation of Wetland Biodiversity

Tiner (2003) identified this as a function performed by uncommon wetland types, postulating that uncommon types help to maintain a diversity of habitats for plant species and animals. Similarly, wetlands with diverse vegetation will rate high on this function because they typically contain a range of microhabitats which supports high species diversity. In Montana, where prairie potholes are common, seasonally flooded Palustrine emergent wetlands only rank as moderate; by contrast,

[21] Species of Concern associated with prairie potholes include the Black-crowned Night-Heron (*Nycticorax nycticorax*), White-faced Ibis (*Plegadis chihi*), Franklin's Gull (*Larus pipixcan*), Common Tern (*Sterna hirundo*), Forster's Tern (*Sterna forsteri*), and Black Tern (*Chlidonias niger*). American White Pelicans (*Pelecanus erythrorhynchos*) feed extensively on tiger salamanders (*Ambystoma tigrinum*) found in prairie potholes.

forested wetlands, saturated wetlands and slope wetlands -- all much less common -- will rank higher. We also gave higher ranks to wetlands created or supported by beaver activity, as beaver presence has diminished in many Montana watersheds as a result of human land uses (Kudray and Schemm 2007).

Of the 54 wetland types we identified, 39 were ranked high on this function, 10 were ranked moderate, and 5 were ranked low.

Ephemeral and Intermittent Streams

Many of the functions performed by isolated wetlands are performed equally well by ephemeral and intermittent streams. Like isolated wetlands, these water bodies provide islands of moisture in dry uplands, creating habitat for plant and animal species, trapping sediments, uptaking and cycling nutrients, and contributing to the maintenance of streams, rivers and lakes. In addition, these small waterways often provide critical corridors between otherwise isolated aquatic ecosystems. These stream also resemble isolated wetlands insofar as they are both hydrologically and biologically variable. In eastern Montana badlands, spring rainfall triggers germination of annual and perennial plant species; many of these plants arise from diverse soil seed banks, parts of which are transported downstream during infrequent flood events (Levick et al. 2007). These same infrequent flood events control the transport of sediment and organic matter deposited during annual rainfalls. Because annual flows in these streams are typically too low to carry materials downstream, much of it is stored and processed onsite before being carried downstream during floods.

Ephemeral and intermittent streams are also vital habitat features for wildlife, especially in the semi-arid landscapes of eastern Montana. These channels can hold enough moisture to support vegetation that is lush in comparison to the surroundings, providing food, shelter, shade, and breeding sites. Intermittent and ephemeral reaches are often interspersed along a channel, with small groundwater pools providing a water source for wildlife and potential amphibian breeding sites. In Eastern Montana, where ephemeral channels flow through woody draws and ravines, tree and shrub communities support diverse bird communities. This section presents the results of our mapping and analysis of ephemeral and intermittent streams.

Unlike perennial streams, which have a stable groundwater source providing continuous surface flow during most of the year, intermittent streams dry out when the groundwater table drops below the streambed surface during dry periods; ephemeral streams, which by definition have no groundwater connection, flow only for short periods during snowmelt or in response to precipitation. The GIS analysis confirmed, that on a statewide basis, ephemeral and intermittent streams far outnumber perennial ones; in fact, throughout most of Montana, these temporary streams are the most common hydrologic feature. In both plains and mountain ecoregions, these streams are the headwaters or important tributaries of perennial rivers, providing hydrologic landscape connectivity, sediment transport and disposition, dissipation of stream energy, nutrient transport and cycling, subsurface and surface water storage and exchange, groundwater discharge and recharge, nutrient cycling, vegetation support, and aquatic and terrestrial wildlife habitat (USFWS 1993; BLM 1998). However, because they lack water for much of the year, these streams are highly susceptible to disturbance from human land use activities.

The predominance of impermanent streams is especially pronounced in the Northwestern Great Plains and Northwestern Glaciated Plains. In some Level IV ecoregions, there are no perennial streams at all. Table 8 gives a breakdown of the distribution of perennial, intermittent and ephemeral streams by Level III and Level IV ecoregions.

Figure 13 shows relative annual effective precipitation (REAP) for the state. In areas where REAP is less than 50cm per year, even intermittent streams are unlikely to have continuous seasonal flow, and perennial streams may become intermittent in sections during irrigation season and/or in drought years. Figure 14 shows the distribution of perennial streams across the state,

Table 8. Perennial, intermittent and ephemeral streams by Level III and Level IV ecoregion

LEVEL III ECOREGION	LEVEL IV ECOREGION	% Perennial	% Intermitt.	% Ephem.
Canadian Rockies	Crestal Alpine-Subalpine Zone	48.16	14.62	37.22
	Flathead Thrust Faulted Carbonate-Rich Mountains	44.64	18.67	36.68
	Northern Front	54.99	19.72	25.30
	Southern Carbonate Front	60.66	17.81	21.53
	Western Canadian Rockies	55.36	13.79	30.85
	Average Canadian Rockies	**52.76**	**16.92**	**30.32**
Idaho Batholith	Eastern Batholith	50.23	9.08	40.69
	Glaciated Bitterroot Mountains and Canyons	51.43	13.20	35.37
	High Idaho Batholith	58.04	11.30	30.66
	Lochsa Uplands	27.27	36.39	36.35
	Average Idaho Batholith	**46.74**	**17.49**	**35.77**
Middle Rockies	Absaroka Volcanic Subalpine Zone	65.22	3.88	30.91
	Absaroka-Gallatin Volcanic Mountains	52.72	17.58	29.71
	Alpine Zone	49.54	18.34	32.13
	Barren Mountains	27.21	29.80	42.99
	Big Belt Forested Highlands	22.60	43.96	33.44
	Big Hole	46.80	12.73	40.48
	Big Snowy-Little Belt Carbonate Mountains	26.82	26.04	47.14
	Bitterroot-Frenchtown Valley	34.57	24.71	40.72
	Centennial Basin	53.76	20.79	25.44
	Crazy Mountains	61.96	11.14	26.90
	Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys	37.87	26.92	35.21
	Dry Gneissic-Schistose-Volcanic Hills	21.15	31.97	46.88
	Dry Intermontane Sagebrush Valleys	24.74	29.02	46.24
	Dry Mid-elevation Sedimentary Mountains	17.00	42.46	40.54
	Eastern Divide Mountains	24.36	40.26	35.38
	Eastern Gravelly Mountains	55.87	20.26	23.87
	Eastern Pioneer Sedimentary Mountains	38.17	25.68	36.15
	Elkhorn Mountains-Boulder Batholith	47.66	19.98	32.36
	Flint Creek-Anaconda Mountains	41.81	26.74	31.45
	Foothill Potholes	41.54	38.78	19.68
	Forested Beaverhead Mountains	61.86	16.31	21.83
	Gneissic-Schistose Forested Mountains	54.00	15.40	30.60
	Granitic Subalpine Zone	97.39	0.66	1.96
	Limy Foothill Savanna	14.04	28.21	57.76
	Mid-elevation Sedimentary Mountains	44.86	21.87	33.27
	Paradise Valley	52.87	15.70	31.43
	Pioneer-Anaconda Ranges	51.68	11.07	37.25
	Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains	37.33	30.83	31.84
	Scattered Eastern Igneous-Core Mountains	14.27	22.02	63.72
	Sedimentary Subalpine Zone	19.55	0.00	80.45
	Southern Garnet Sedimentary-Volcanic Mountains	32.20	37.34	30.46
	Tobacco Root Mountains	48.26	19.01	32.73
	Townsend Basin	20.76	32.15	47.09

Table 8. Perennial, intermittent and ephemeral streams by Level III and Level IV ecoregion (Continued)

LEVEL III ECOREGION	LEVEL IV ECOREGION	% Perennial	% Intermitt.	% Ephem.
Middle Rockies	Townsend-Horseshoe-London Sedimentary Hills	13.59	37.81	48.59
	Western Beaverhead Mountains	18.38	51.49	30.12
	Yellowstone Plateau	48.87	31.43	19.69
	Average Middle Rockies	**39.48**	**24.51**	**36.01**
Northern Rockies	Camas Valley	19.08	47.10	33.82
	Clark Fork Valley and Mountains	35.09	18.05	46.86
	Coeur d Alene Metasedimentary Zone	35.87	15.00	49.14
	Flathead Hills and Mountains	13.98	45.50	40.53
	Flathead Valley	37.67	28.78	33.56
	Grave Creek Range-Nine Mile Divide	29.78	27.34	42.88
	High Northern Rockies	30.36	20.62	49.02
	Purcell-Cabinet-North Bitterroot Mountains	43.13	18.20	38.67
	Salish Mountains	31.50	31.88	36.62
	St. Joe Schist-Gneiss Zone	43.70	16.50	39.81
	Stillwater-Swan Wooded Valley	53.32	20.51	26.18
	Tobacco Plains	50.87	20.51	28.62
	Average Northern Rockies	**35.36**	**25.83**	**38.81**
Northwestern Glaciated Plains	Cherry Patch Moraines	0.00	20.78	79.22
	Collapsed Glacial Outwash	55.89	17.95	26.15
	Coteau Lakes Upland	8.99	24.43	66.58
	Foothill Grassland	15.71	31.37	52.92
	Glaciated Dark Brown Prairie	8.61	28.24	63.15
	Glaciated Northern Grasslands	3.25	23.92	72.83
	Milk River Pothole Upland	2.23	30.37	67.40
	North Central Brown Glaciated Plains	6.05	36.35	57.60
	Northern Missouri Coteau	2.22	0.00	97.78
	Rocky Mountain Front Foothill Potholes	26.70	29.07	44.23
	Sweetgrass Uplands	5.34	34.90	59.75
	Average Northwestern Glaciated Plains	**12.27**	**25.22**	**62.51**
Northwestern Great Plains	Central Grassland	6.96	34.49	58.55
	Dense Clay Prairie	0.00	38.68	61.32
	Forested Buttes	0.32	32.34	67.35
	Judith Basin Grassland	17.93	34.30	47.77
	Limy Foothill Grassland	14.99	37.76	47.25
	Little Missouri Badlands	0.13	41.81	58.06
	Mesic Dissected Plains	6.92	35.77	57.31
	Missouri Breaks Woodland-Scrubland	8.66	29.81	61.53
	Missouri Plateau	3.26	32.27	64.47
	Non-calcareous foothill grassland	32.52	25.22	42.27
	Ponderosa Pine Forest-Savanna Hills	4.67	37.40	57.93
	Pryor - Bighorn Foothills	13.64	31.47	54.90
	Pryor-Big Horn Foothills	11.54	48.92	39.54
	River Breaks	9.77	35.33	54.90

Table 8. Perennial, intermittent and ephemeral streams by Level III and Level IV ecoregion (Continued)

LEVEL III ECOREGION	LEVEL IV ECOREGION	% Perennial	% Intermitt.	% Ephem.
Northwestern	Sagebrush Steppe	4.02	38.63	57.35
Great Plains	Semiarid Pierre Shale Plains	6.89	14.85	78.26
	Shield-Smith Valleys	36.36	27.91	35.72
	Unglaciated Montana High Plains	17.88	28.31	53.81
	Average Northwestern Great Plains	**10.91**	**33.62**	**55.46**
Wyoming Basin	Bighorn Basin	8.64	50.70	40.67
	Bighorn Salt Desert Shrub Basin	41.21	0.00	58.79
	Average Wyoming Basin	**24.92**	**25.35**	**49.73**

and underscores the relationship between stream permanence and climate factors.

Our characterization of a given stream as "perennial," "intermittent" or "ephemeral" has varying levels of confidence attached. USGS topographic maps, the basis for the National Hydrography dataset, are based on aerial photo interpretations. Both the topo maps and the NHD have been extensively field-verified by the USGS, and the classifications of perennial vs. intermittent streams are considered satisfactory (Simley 2007). In most of Montana, perennial streams are easy to detect on aerial photos, and so we are confident these features are properly classified, and that few, if any, perennial streams have been overlooked.

However, the USGS acknowledges some stream features (particularly intermittent and ephemeral ones) in extremely wet areas with high stream density may be underrepresented, while features in drier areas with lower stream density may be overrepresented (Simley 2007). We did not find evidence of underrepresentation of stream

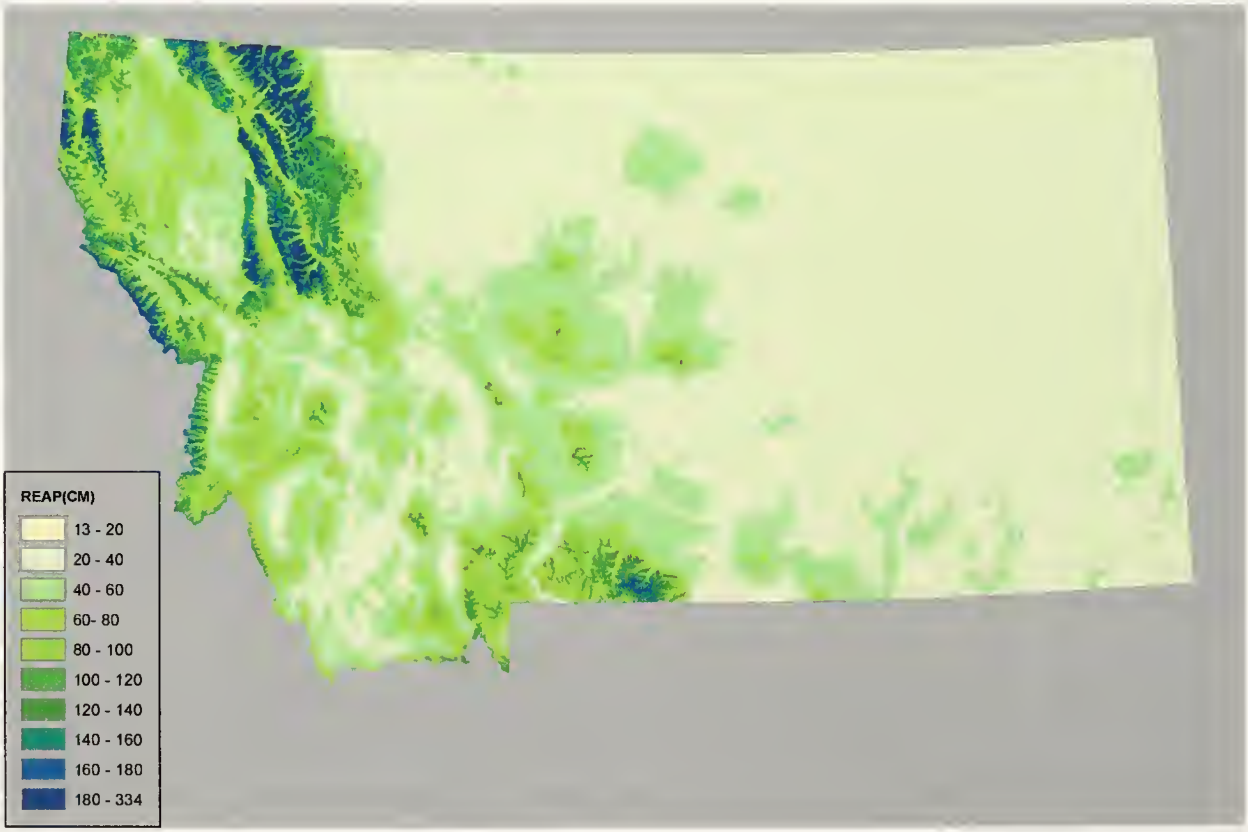

Figure 13. Relative effective annual precipitation

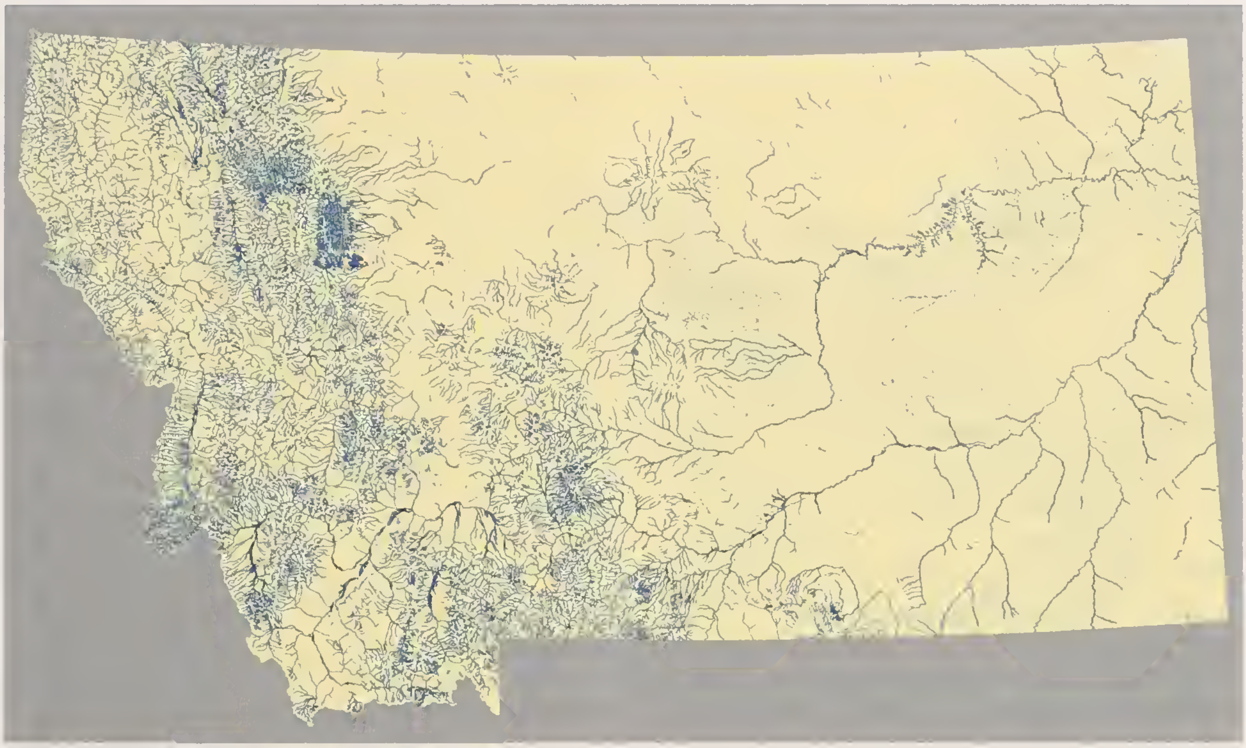

Figure 14. Perennial streams

features in wet, mountain areas when we ran our initial models and verified them with aerial photos. However, we did note that many of the "intermittent" features in the plains appearing only on the high-resolution NHD -- features we reclassified as ephemeral -- are very shallow, linear depressions with only a moderate slope, suggesting that if they run at all, it is only during very extreme events. Therefore, while we are confident most of the features identified as intermittent in the medium resolution NHD are correctly classified, we caution the reader that our classification of "ephemeral" is based entirely on a modeled interpretation of the high-resolution data. These are the features most likely to be overrepresented; it is possible some of the identified features never contain running water.

It is also likely many streams that are actually intermittent have been classified as ephemeral and vice-versa. We inspected aerial photographs to verify our classifications, but it was not feasible to conduct systematic verification on a statewide basis. Moreover, even in our field surveys, we were not always able to distinguish ephemeral streams from intermittent ones, as this requires field-based indicators that have previously undergone extensively calibration to different environmental contexts. Even then, classification accuracy may be low (Fritz et al. 2008). In areas where climate and geology are relatively homogeneous, it might be possible to correlate drainage area and permanence, and draw more conclusive inferences from a GIS (Wolock et al. 2004, Fritz et al. 2008), but hydrologic permanence can vary within individual streams in response to interannual shifts in precipitation (Hunter et al. 2005). Therefore, we remind the reader that the category of "ephemeral" streams probably contains both truly ephemeral streams and streams having some groundwater connection. What sets these streams apart from streams we have labeled as "intermittent" is primarily size and duration of flow. Consequently, our "ephemeral" stream category should be understood as including truly ephemeral streams and streams having some groundwater source in some years, but low and infrequent flows.

Discussion

We again caution that this is a GIS analysis only, and that our classification of wetlands and riparian areas cannot be considered definitive. Jurisdictional determinations can only be made by agency personnel, and requires site-specific analysis. Furthermore, interpretations of the Clean Water Act, agency guidance and jurisprudence are always subject to revision. Nonetheless, the analysis indicates that the majority of mapped wetlands in Montana, because of their geographic isolation, may fall entirely outside of the scope of Clean Water Act protection. It also underscores an especially difficult challenge for resource management; many of Montana's wetlands and streams will not meet the thresholds necessary for assertion of Clean Water Act jurisdiction without a detailed and potentially protracted investigation of "significant nexus". This translates to an unrealistic workload for agency personnel charged with making jurisdictional determinations, ensuring growing backlogs of permit applications and a probable decrease in enforcement actions. At the same time, it leaves landowners and resource managers in a state of uncertainty, not knowing what actions will require permits and not being able to predict how much time it will take to process a request.

This study takes an important first step towards characterizing the extent and distribution of legally vulnerable wetlands and streams. However, it leaves many questions unanswered. We know very little about hydrologic and ecological interactions between isolated wetlands and nearby streams and rivers, and less still about interactions between ephemeral, intermittent, and perennial streams. As Levick et al (2007) observed, the variability inherent in these systems and the episodic nature of the extreme events linking them translates to a need for long-term data and observations. This is especially true in an era where climate appears to be changing rapidly, disrupting the cycles having shaped these resources. Unfortunately, research of this nature can only be conducted on small scales or on very specific types of wetlands.

Because wetland mapping is incomplete in Montana, the part of this study dealing with wetlands is also incomplete. We know a great deal about the types and sizes of isolated wetlands in the Northwestern Glaciated Plains because that area is almost completely mapped. We know far less about isolated wetlands in other parts of the state. We have very little information on springs and seeps in the Wyoming Basin, or on Rocky Mountain vernal pools in the Northern Rockies, or about fens and kettle ponds in the Middle Rockies. Without mapping, other research is often impeded. For example, we have been able to identify changes in wetland resources in rapidly urbanizing valleys (Kudray and Schemm 2007, Newlon and Burns 2009) because we have the maps required for the analysis, but we have no easy way to track change over time in areas where no digital maps exist. When we lay NWI maps over aerial photos of the Northwest Glaciated Plains, it is clear there have been losses and alterations in some areas, but this has not been explored systematically. If we knew how many isolated wetlands have been converted or lost over the past twenty years, we might be able to predict trends for the future, and in so doing identify areas where important wetland complexes are in danger of losing their integrity. Similarly, wet meadows in the alpine and subalpine zones are almost entirely unmapped, despite their importance for streamflow maintenance and nutrient cycling, and despite their position on the "front line" of climate change. Because we know so little about their distribution, we cannot begin the kind of systematic baseline data collection, assessment and monitoring needed to detect changes over time.

Despite the limitations, this study provides an initial characterization of isolated wetlands in Montana, and describes a GIS approach for their identification applicable to other areas as maps become available. We hope its findings are useful to resource managers charged with the challenge of ensuring the important functions of isolated wetlands, and intermittent and ephemeral streams, are not lost or impaired.

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